

Appendix C. BEST MANAGEMENT PRACTICES

This appendix provides a detailed description of the Best Management Practices (BMPs) described in Chapter 3. The BMPs are divided into 12 general categories:

- 1) Drainage Control
- 2) Trails in Wet Areas
- 3) Trails on Steep Cross Slopes
- 4) Trails on Flat Grades
- 5) Eroding and Hazardous Trail Edges
- 6) Trails on Sandy Soils
- 7) Trails Damaged by Vehicle Use
- 8) Bicycle Safety Improvements
- 9) Social Trails Requiring Closure
- 10) Trails in Proximity to Sensitive Resources
- 11) Air Quality
- 12) Natural Resource Conservation

1. Drainage Control

Trails in hilly terrain are particularly subject to erosion caused by water movement. Design and construction errors can allow water to build up volume and velocity, which often causes trail damage. There are several basic design strategies to improve drainage control, such as using alignments perpendicular to sheetflow direction and full or half bench construction. Figure C-1 illustrates a typical location of existing, non-accessible drainage control measures.



Figure C-1. Typical Location: Existing Drainage Control

1-1 Outsloping

Outsloping is slightly elevating the uphill edge of a trail. It encourages water to flow across the trail surface and reduces the potential for erosion. All proposed trail designs include outsloping. Full bench construction provides a more stable trail bed (Figure C-2). Where cross slopes are not steep (generally less than 30 percent), half bench construction may be used.

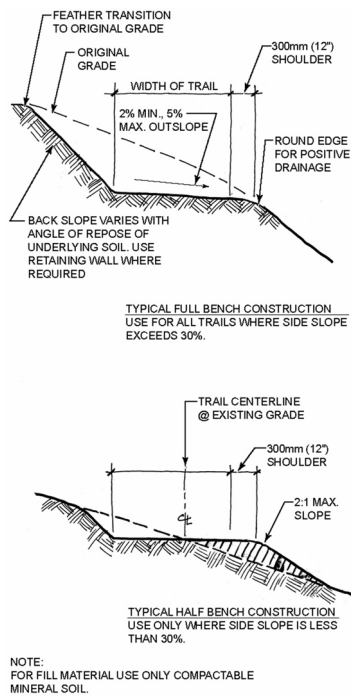


Figure C-2. Outsloping (BMP 1-1)

1-2 Rolling Grade Dips

Rolling grade dips are short sections of trail that channel water off the trail surface. Grade dips work best on trails with slow, steady grades and are best placed at naturally occurring drainage ways (Figure C-3). Typically, trails are outsloped more at the point of the grade dip to provide better drainage. Grade dip backslopes should be about 1.2 to 1.8 m (4 to 6 ft) long to eliminate abrupt grade changes that may be barriers to access. For this reason, dips are preferable to both waterbars and open culverts. They typically require less maintenance than covered culverts, which can easily become clogged with leaves or other debris.

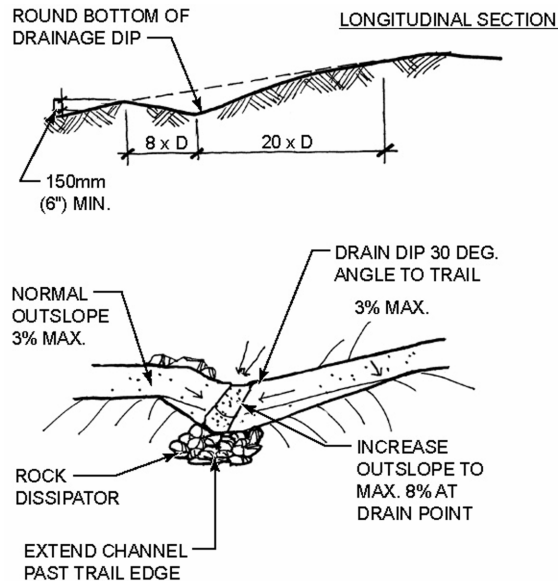


Figure C-3. Rolling Grade Dip (BMP 1-2)

2. Trails in Wet Areas

Trails in the proximity of areas with seasonal or permanent soft and water-saturated soils pose problems for visitor enjoyment and for resource protection and maintenance.

Trail users often walk to trail sides to avoid wet patches, and that can cause destruction of adjacent vegetation and surface soil horizons. However, relocating these trails to higher or drier ground may not be the answer if the existing trail provides special benefits to users or if rerouting the trail would disturb sensitive habitat areas. Providing a hardened trail surface in the current trail alignment may be the best choice. Techniques that allow access for users with disabilities are preferred.

2-1 Surface Reinforcing

Placing flat stones or cobbles on the trail surface, in combination with geotextile or sheet drain materials, is an aesthetically pleasing way to provide a stable trail surface in wet areas. Since water can pass through the entire structure, this solution offers the additional advantage of only minimally

disrupting existing drainage patterns (Figure C-4). Another alternative is a short, concrete-paved section that would be more accessible for people using wheelchairs.

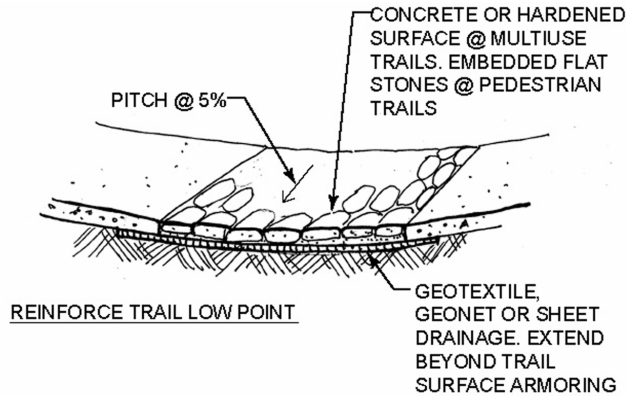


Figure C-4. Surface Reinforcing (BMP 2-1)

2-2 Boardwalk Bridge

Trail structures such as bridges help maintain drainage patterns. They can be constructed of timber or recycled plastic lumber (Figure C-5). To maximize accessibility for people with disabilities, bridge entrances and exits should be at grade rather than elevated or ramped. Additional maintenance might be required to ensure that surfaces that adjoin the entrances and exits do not vary more than 50 mm (2 in) from the bridge surface.

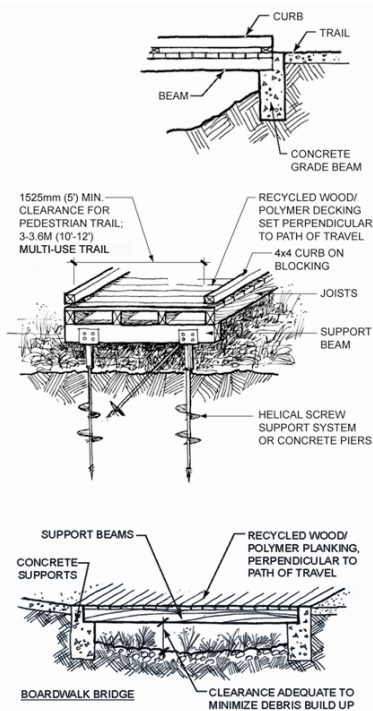


Figure C-5. Boardwalk Bridge (BMP 2-2)

2-3 Drainage Lens

The low-volume water flow caused by ephemeral springs or seeps can often be managed with a drainage lens (Figure C-6). The area beneath the trailbed should be filled with progressively smaller quarry rock and then capped with fine aggregate or suitable native fill. Sandwiching the rock lens between two layers of geotextile material would provide a more stable base, and would prevent rock from mixing with surrounding soils.

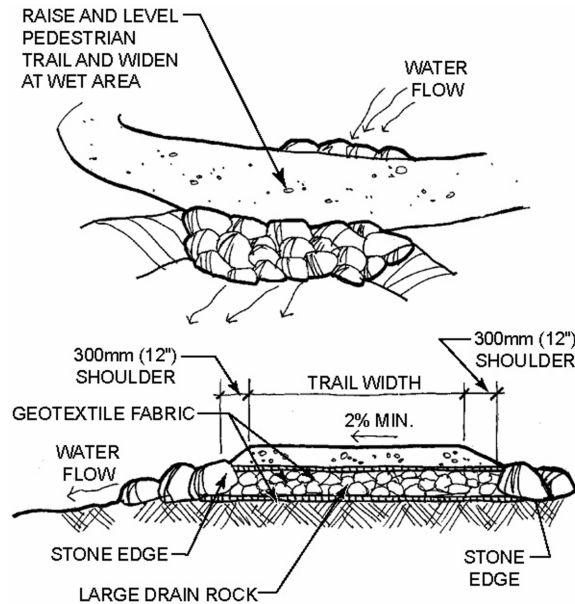


Figure C-6. Drainage Lens (BMP 2-3)

3. Trails on Steep Cross Slopes

As illustrated in Figure C-7, steep slopes present many challenges for safe and sensitive trail design. Trail cuts on steep slopes increase the visual impact and the area of disturbance and often require special measures to stabilize the slope, such as slope protection or retaining walls. In some cases, stairways may also be needed. Trail structures and retaining walls, when required, should be designed to minimize impact on natural and cultural resources and should use materials appropriate to the



area's landscape management zone.

Figure C-7. Typical Location: Steep Slopes

3-1 Area Avoidance and Trail Relocation

When possible, avoid locating trails on steep slopes. Where trails must cross a steep slope, consider a minimum width trail.

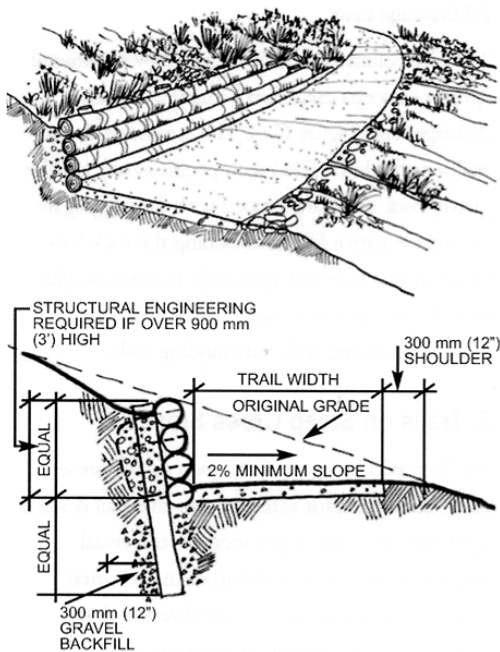
3-2 Reinforced Backslope or Retaining Wall

Depending on soil type, backslope cuts into hillsides may need protection in order to prevent severe erosion and slope destabilization. Table C-1 illustrates typical backslope cut ratios. Backslope reinforcing and protection can be provided by a permanent structure or by temporary measures during revegetation.

Table C-1. Backslope Cut Ratios

Soil Type	Ratio (horizontal to vertical)
Sand	3 or 4:1
Moist clay	2 or 3:1
Loose, gravelly soil	1.5 or 2:1
Loose rock	0.5:1
Stable rock	0.25:1

Retaining devices may be as simple as a log curb, or they may need to be designed by a structural engineer. Retaining materials may be poured-in-place or precast concrete segments, stones or timber from vegetation management practices, depending on the landscape management zone. Figure C-8 illustrates the features of a typical retaining wall. All retaining structures must allow water to drain around or through the wall and not accumulate behind it. Stepped-back wall construction may provide opportunities for more planting. Green wall systems (a structure permeated by plantings) may be an acceptable alternative to retaining walls in some areas of the Presidio. Ongoing maintenance, including repair, replacement and removal of broken or detached components, must be provided for all retaining structures.

**Figure C-8. Retaining Wall (BMP 3-2)**

3-3 Trail Structure

Boardwalks, stairways, and decks may be used where standard cut-and-fill techniques are inappropriate (Figure C-9). For example, on steep trails on sandy or loose soils, stairways are recommended to avoid excessive erosion. Steel deck structures would allow light to penetrate to the vegetation below and reduce impacts on habitats sensitive to light.

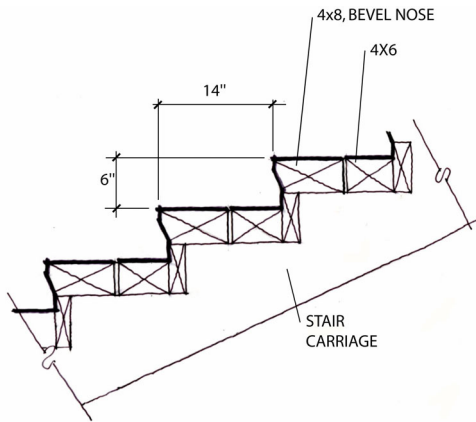


Figure C-9. Trail Stairs (BMP 3-3)

4. Trails on Flat Grades

Since trails exist in dynamic environments, it is not possible to keep them clean and dry – especially when they're on primarily level terrain. Without proper drainage, trails on level ground tend to pond and collect debris, creating obstacles for all users. This creates a cycle that further degrades the trail and surrounding lands. Proper trail design can help mitigate this problem. There are several approaches for providing good drainage. The goal in all cases is to maintain a firm, stable, slip-resistant surface that is free of ponding.

4-1 Above Grade Trail

One technique is to elevate a trail slightly, about 75 mm to 150 mm (3 in to 6 in), and provide drainage swales on each side (Figure C-10). Using a gravel bed to elevate the trail would provide additional subsurface drainage. Raised trails are often used in conjunction with drainage lenses to facilitate water movement. An elevated trail offers a more convenient pathway for users during wet periods, provides the greatest degree of accessibility for persons with disabilities, and may require less maintenance.

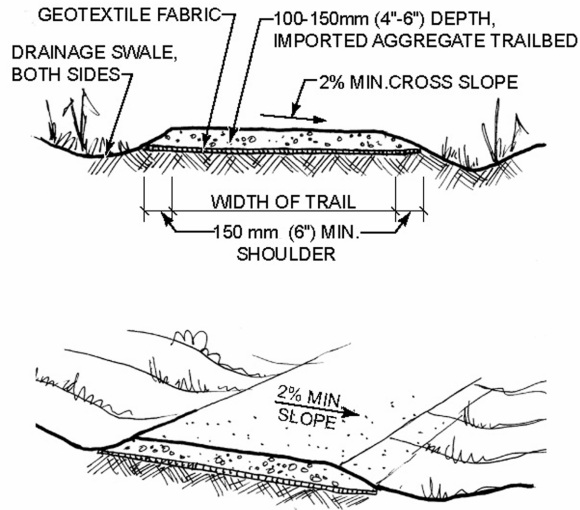


Figure C-10. Above Grade Trail (BMP 4-1)

4-2 Boardwalks

This approach, described in BMP 10-2, Trails in Proximity to Sensitive Resources, also provides an accessible trail surface. Boardwalks are often the most appropriate solution on erodible soils, such as sand or other loose, uncompacted soil.

5. Eroding and Hazardous Trail Edges

Edge protection has two purposes: to protect the trail and adjacent resources, and to protect the user.

Clearly defined edges help keep users of all types on the established trail surface and help protect resources. Properly constructed edges also protect trails from water damage and erosion. Figure C-11 illustrates typical eroding and hazardous trail edges.

Edge protection can also increase trail safety for various user groups. For example, a raised curb at least 75 mm (3 in) high or a guardrail may help a person using a wheelchair keep on track. However, some types of edge protection may be hazardous for bicyclists.



Figure C-11. Typical Location: Eroding and Hazardous Trail Edges

5-1 Edge Stabilization

Edge protection is sometimes required to stabilize the trail structure, and prevent erosion of edges and eventual undermining of the trail base. Reinforcement of both sides of the trailbed can improve long term sustainability. Soft surfaces such as those proposed for walking or jogging on the edges of multi-use trails generally require full-depth edge protection to prevent breakdown of trail edges.

Since Presidio trails pass through many different environments, including sensitive natural habitat or historically significant landscapes, edge protection should be consistent with the setting. Trails requiring edge protection in the VMP Landscape Management Zone or in areas of high use and urban character might use more traditional materials such as curbs, manufactured or cut stones, and railings. In other VMP zones, edge protection could be provided by native materials, including plants, salvaged logs (from vegetation management practices), or natural stones (Figure C-12). It must be installed to facilitate water flow across the trail, and openings must be adequate to allow organic material to pass through them.

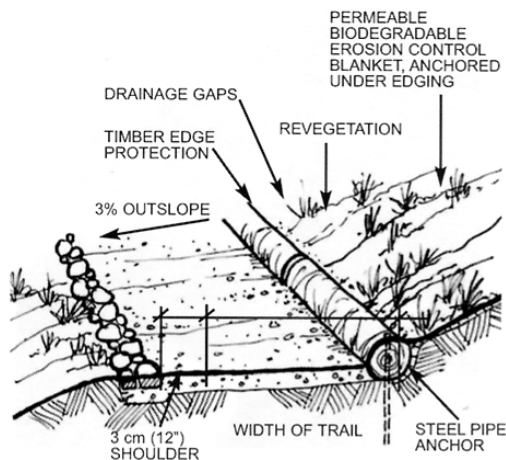


Figure C-12. Edge Protection: Trail Setting (BMP 5-1)

5-2 Edge Safety

Trail edge safety provisions are sometimes required and must be appropriate to the trail user group and the setting. On multi-use trails, edge protection and barriers must be designed for bicycle safety. For example, a raised curb that might aid a wheelchair user should not be located immediately adjacent to a bicycle way or paved portion of a multi-use trail, unless the trail is widened to provide buffers. All vertical structures such as curbs and railings should be set back a minimum of 0.6 m (2 ft) from the bicycle way.

Where required for trail user safety immediately adjacent to a steep drop off, safety railings with a height of 1.1 m (42 in) should be provided. However, because railings can be a visual intrusion in a natural setting, they should be used only when there is no other alternative.

5-3 Reducing Hazards at Drop-offs

An effective strategy for reducing hazardous conditions on hillside trails (with or without additional edge protection) is to widen the trail and plant vegetation at the trail's edge.

6. Trails on Sandy Soils

Maintaining a stable trail surface can be particularly challenging in areas with sandy soils (Figure C-13). Solutions depend on factors such as the relative sensitivity of the surrounding habitat, continuing maintenance costs, accessibility requirements, and issues specific to each landscape management zone.



Figure C-13. Trails in Sandy Soil

6-1 Subsurface Geogrids

Geogrids or geocells, when used in combination with geotextiles, provide a relatively unobtrusive means of stabilizing sandy trails (Figure C-14). The geogrid confinement chambers distribute trail

tread loads over a greater area and reduce settling, both of which help keep trail surfaces intact, in place and dry. The geotextile material provides separation between saturated soil and the tread fill, or increased containment over a sand base. Permeable tread fill provides drainage if the trail is built with a grade or on a sideslope. Imported soils should not be used for tread fill in areas of sensitive natural habitat.

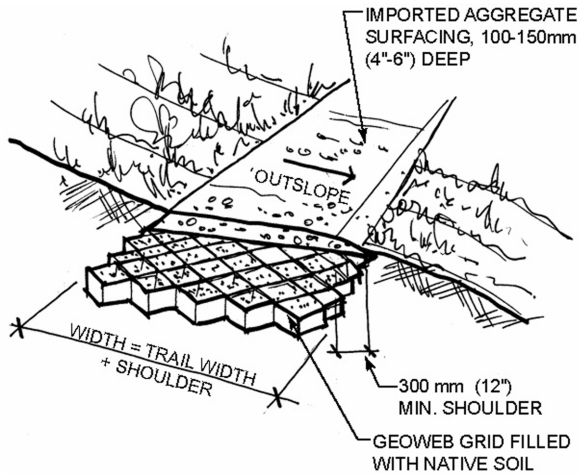


Figure C-14. Subsurface Geogrid (BMP 6-1)

6-2 Permanent and Moveable Above-Grade Trail Structures

Boardwalks, which are permanent trail structures described in BMP 10-2, Boardwalks, are traditionally used for access across sandy soils. Another option is textured panels with drain holes, which are installed directly on the surface without excavation (Figure C-15). These panels meet current accessibility guidelines and can be relocated. They may require additional maintenance, such as sweeping and readjustment of linked panels to provide a uniform surface.

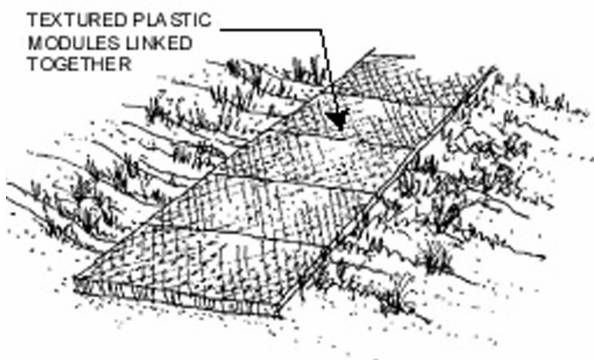


Figure C-15. Moveable Textured Panel (BMP 6-2)

Sand ladders are a series of logs connected by cable, such as the one in use on the dunes just south of Battery Crosby (Figure C-16). They are an option for sandy trails with a steep linear grade. Sand

ladders do not provide an accessible route for people with disabilities. Periodic maintenance is required to restore sand ladders to grade level after sand accumulates on the surface.

Although temporary or moveable beach access routes are permitted, there are currently no recommendations for products that meet accessibility requirements. However, several products have been evaluated by the National Center on Accessibility and should be further evaluated by NPS.



Figure C-16. Sand Ladder (BMP 6-2)

7. Trails Damaged by Vehicle Use

As illustrated by Figure C-17A, maintenance vehicles can damage trails that were not designed to support vehicular traffic. Trail structural stability and strength should be increased on pedestrian and multi-use trails that will be used by maintenance vehicles. Since many Presidio trails are located in areas where sub-grades have a low bearing strength or are poorly drained, sub-bases and trail surfaces would need to be thicker than standard practice to support greater design loads.



Figure C-17A. Trail Damaged by Vehicle Use

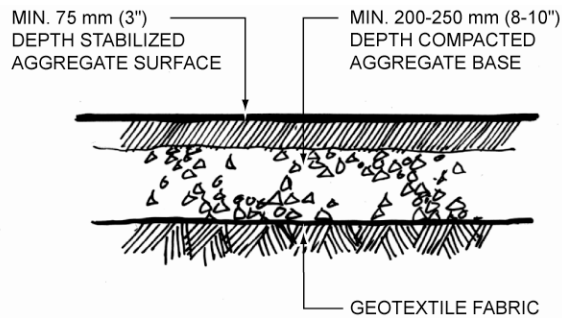


Figure C-17B. Reinforced Trail Base (BMP 7-1)

7-1 Geotextile Underlay and Deeper Sub-Base

Geotextiles can promote trail structural stability and increase the strength of trail cross sections. Wherever maintenance vehicle use is expected, geotextiles should be used to keep trail sub-bases intact and reinforce the structural qualities of trail sub-grades. In some cases, the depth of trail sub-bases should be increased to 0.2 m (8 in).

8. Bicycle Safety Improvements

The Presidio is located in a highly urbanized setting. Many bicycles and automobiles pass through the Presidio on roads linking San Francisco to the Golden Gate Bridge. As a result, there is high potential for user conflicts at road intersections or at road-trail intersections. Figure C-18 illustrates one area of bicycle/automobile conflict. Recent studies indicate that 50 to 70 percent of bicycle and motor vehicle crashes nationally are at intersections and intersection-related locations. In addition, the public has expressed concern about pedestrian safety and the potential for user conflicts.



Figure C-18. Typical Location: Bicycle/Auto Conflict on Washington Boulevard

8-1 Roadway Narrowing

In conjunction with bicycle lanes, narrowing roadways can reduce motor vehicle speed, increase safety, and redistribute space to bicyclists and pedestrians. Roadway narrowing can be accomplished by reducing motor vehicle lane widths, removing travel lanes, or converting wide shoulder parking areas to bike lanes. Roadway improvements to improve safety along Lincoln Boulevard at the coast have been identified as a high priority by the public and by researchers (Peccia 1994).

8-2 Crossing Island/Curb Extensions

Physical measures, such as installing crossing islands or curb extensions, are another means of narrowing roadways and increasing safety. To maximize accessibility, crosswalks should cut through crossing islands at the same elevation as the roadway. Curb extensions may be appropriate in residential areas, but should only be used where there are on-street parking lanes so that the curbs do not extend into travel or bicycle lanes. Curb radius reduction is particularly effective in improving pedestrian safety at crossings by slowing right-turning vehicles, reducing crossing distances, and improving visibility between drivers and pedestrians.

8-3 Raised Intersection and Raised Pedestrian Crossing

Raising an entire intersection or crosswalk is an effective means of encouraging motorists to yield the right of way to pedestrians. Tactile warning strips at edges enable people with visual disabilities to detect the crossings. Since these devices also slow down emergency vehicles, their placement should be limited and these intersections should have adequate sight distances. This technique might be appropriate where a multi-use trail crosses the road or at intersections in the Main Post (such as on Moraga Street and Lincoln Boulevard) that have been identified as hazardous by both the public and researchers (Peccia 1993).

8-4 Specific Paving Treatments

Paving treatments can visually delineate space for pedestrians and bicyclists. Paving can be used alone or with BMP 8-3, Raised Intersection and Raised Pedestrian Crossing, to increase pedestrian and bicycle safety. Textured crosswalks, speed bumps and colored bike lanes are examples of paving treatments used to visually delineate crosswalks and bike lanes.

Textured crosswalks can be visual and tactile markers for pedestrian traffic, and also can provide aesthetic enhancement. However, crosswalks should not be constructed of materials that create unsafe or inaccessible conditions for bicyclists or people with disabilities. Since textured paving might not be visible at night, it should also be marked with reflective lines. Installing textured crosswalks at key points where trails intersect the roadway could reduce speeding through the Presidio's housing areas. Colored bike lanes are still under study in the United States. They have proved to be effective in increasing bicycle safety in many European countries.

8-5 Roadway Lighting Improvements

Improved lighting enhances security and safety for all roadway users, particularly pedestrians. Commuter routes through the Presidio and from Presidio employment centers to housing and transit stops would benefit from improved lighting, particularly where pedestrian trails intersect with or cross roadways. Additional lighting would only be installed after careful consideration of wildlife and night sky sighting impacts.

8-6 Multi-Use or Pedestrian Trail Overpasses

Traffic calming measures cannot always provide adequate pedestrian or bicyclist safety where trails or bikeways cross busy streets. A pedestrian or multi-use trail overpass can connect off-street trails and paths across major barriers and provide complete separation from motor vehicle traffic. One appropriate location for an overpass is where the Bay Area Ridge Trail crosses Lincoln Boulevard from Fort Scott to the coastal batteries, near the intersection with Storey Avenue. Sight distance is short and vehicle speed is fast. Grade change on both sides of the road would reduce the visual impact of an overpass.

8-7 Special Roadway Intersection Treatments

Separating multi-use trail user groups at intersections can reduce confusion at trail-roadway intersections. Each intersection could be used as an entry/exit point by users and should be considered a transition zone. Separate entrances/exits or trailheads for user groups – buffered from each other – increase trail users' awareness at intersections. Adjustments to multi-use trail alignments, such as jogs, offsets, or sharp bends near the intersection, help to slow bike traffic and alert users to the intersection. Clear directional signage at these intersections should be provided.

8-8 Traffic Controls

Pedestrian and bicyclist safety can be improved at roadway/trail intersections with the addition of traffic lights and signage, such as stop signs. These improvements would be coordinated with Presidio transportation planning.

8-9 Narrow Gutter Pans

Bicyclist safety can be improved by minimizing the width of gutter pans. Where feasible, the width of gutter pans should be minimized, particularly where bike lanes are five feet or less in width.

8-10 Safe Bicycle Grates

Bicyclist safety can be improved by installing bicycle proof grates in drainage openings. Where feasible, existing grates will be replaced with bicycle proof grates such as those specified by Caltrans.

9. Social Trails Requiring Closure

As noted in the VMP, the Presidio provides a shelter for remnants of San Francisco's natural heritage, including communities of native plants, rare and endangered species, important wildlife habitat, and the last free-flowing stream in the city. Off-trail hiking and the development of social trails is a serious threat to native plant communities in the Presidio (Figure C-19). Although considered convenient by users, social trails are often unsafe, contribute to the loss of plant communities, and disturb wildlife. They also impact water resources through erosion and soil compaction. In order to protect the Presidio's unique natural resources, some social trails would be closed.

9-1 Entrance Point Closures and Signs

Obscuring the entrance to social trails with brush piles or permanent or temporary barriers, such as fences and signs, can discourage the use of social trails. Fencing should be kept to a minimum or used as a temporary measure to protect revegetation areas until these areas are well established. Trail closure signs might be installed temporarily until vegetation is established. Signs or notices posted at trailheads can inform people of the need for social trail closures and encourage them to comply with trail closures. Natural resources staff would help time the trail closures, to ensure that there is adequate time for seed and/or plant collection and salvage, and nursery propagation for revegetation.



Figure C-19. Social Trail Through Forest

9-2 Vegetation Restoration

Figure C-20 shows several effective techniques that can be used to rehabilitate areas damaged by social trails. For instance, it might be necessary to camouflage the trail surface to discourage continued use. One technique is vertical mulch or brushing-in, where materials are collected from the immediate vicinity and "planted" into the trail surface. Vertical mulch can facilitate the deposition of blowing soil, organic debris, and seeds while creating a protected site for plant reestablishment. Specific prescriptions for plant establishment would be done in consultation with park vegetation restoration specialists. In heavily eroded areas, native soil fill, grading, and temporary check dams may help slow and disperse water flow and encourage the deposition of sediments in ruts or low points.

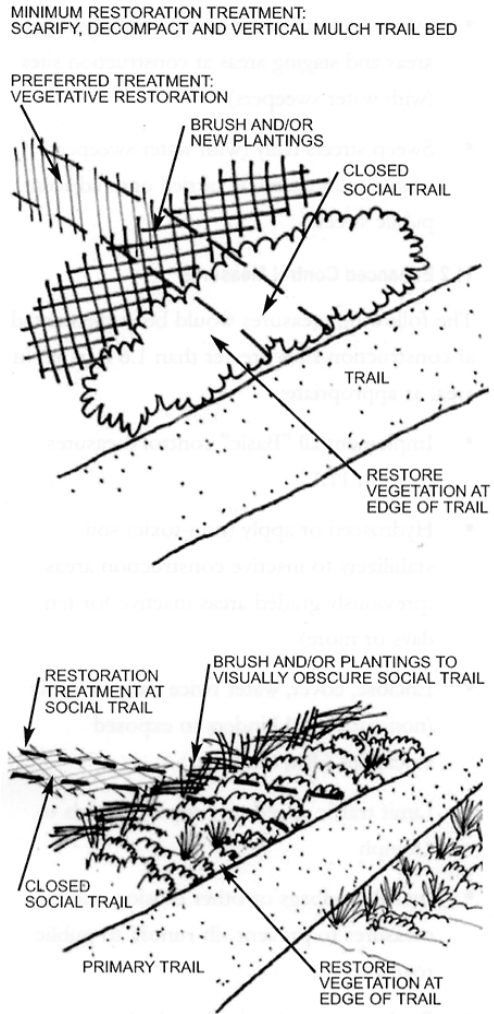


Figure C-20. Vegetation Restoration (BMP 9-2)

10. Trails in Proximity to Sensitive Resources

Visitor access to the Presidio's natural, cultural, and historic resources must be constructed to provide as much protection as possible to these sensitive resources. Figure C-21 illustrates the typical location of a trail in close proximity to sensitive resources. The following BMPs should be applied when developing trails in proximity to sensitive resources:



Figure C-21. Lobos Creek Boardwalk

10-1 Multi-Use or Pedestrian Trail with Barrier

Designated interpretive routes for Presidio visitors would help minimize the damage to sensitive resources caused by social trails. Providing multi-use trails would allow access, while encouraging all users to stay on established routes. Planted barriers can also be an effective means of keeping visitors on trails. If this approach is not feasible, fences that are compatible with each landscape management zone are another design option.

10-2 Boardwalks

Boardwalks, permanent trail structures often used in sensitive areas, are more easily constructed with minimum impact to the environment than standard trails. They also encourage people to stay on the designated trail. An important consideration in boardwalk design is to ensure that the need for two people using wheelchairs to pass each other is taken into account in the design.

Providing pullouts or overlook alcoves is another way to increase accessibility by allowing resting or observation without impeding the movement of other trail users. Boardwalk decking should be installed perpendicular to the direction of travel. Figure C-22 illustrates a boardwalk construction detail and typical cross section.

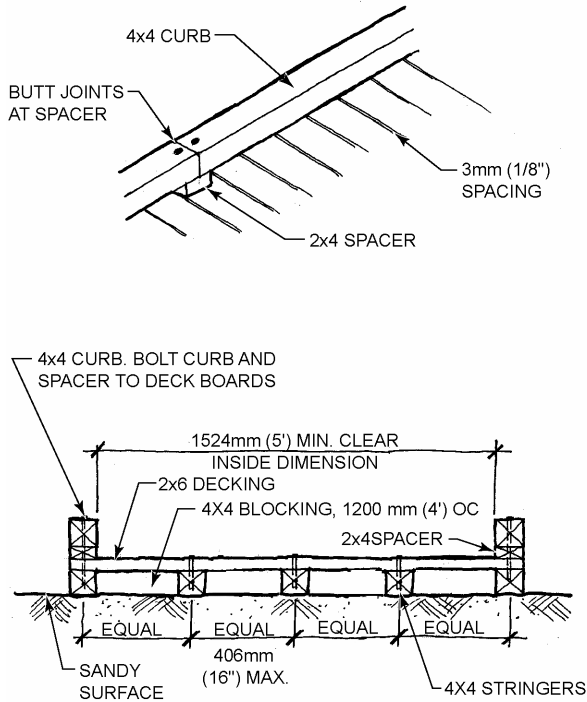


Figure C-22. Boardwalk (BMP 10-2)

10-3 Moveable Panels

Moveable textured panels can be used in areas in proximity to sensitive resources. They are described in BMP 6-2, Permanent and Moveable Above Grade Trail Structures.

10-4 Annual Trail Relocation

Periodically relocating non-permanent boardwalk and/or moveable textured panel trails can minimize trail impacts and permit previously disturbed areas to recover.

10-5 Bioswales

Non-point source pollution can be reduced by treating runoff in bioswales before it enters creeks or storm drains. Where feasible, bioswales may be used adjacent to trails to treat runoff.

11. Air Quality Measures

Fugitive Dust Control

11.1 Basic Control Measures

The following controls would be implemented at all construction sites, as appropriate:

- Cover all trucks hauling soil, sand and other loose materials or require all trucks to maintain at least two feet of freeboard
- Water all active construction areas at least twice daily
- Pave, apply water three times daily or apply (non-toxic) soil stabilizers on all unpaved access roads, parking areas and staging areas
- Sweep daily all paved access roads, parking areas and staging areas at construction sites (with water sweepers)
- Sweep streets daily (with water sweepers) if visible soil material is carried onto adjacent public streets

11.2 Enhanced Control Measures

The following measures would be implemented at construction sites greater than 1.6 h (4 ac) in area, as appropriate:

- Implement all "Basic" control measures listed in 11.1
- Hydroseed or apply (non-toxic) soil stabilizers to inactive construction areas (previously graded areas inactive for ten days or more)
- Enclose, cover, water twice daily or apply (non-toxic) soil binders to exposed stockpiles (dirt, sand, etc.)
- Limit traffic speeds on unpaved roads to 15 mph
- Install sandbags or other erosion control measures to prevent silt runoff to public roadways
- Replant vegetation in disturbed areas as quickly as possible

11.3 Optional Control Measures

The following control measures would be encouraged at construction sites that are large in area, located near sensitive receptors, or if any other reasons may warrant additional emissions reductions:

- Install wheel washers for all exiting trucks or wash off the tires or tracks of all trucks and equipment leaving the site
- Install wind breaks or plant trees/vegetative wind breaks at windward side(s) of construction areas
- Suspend excavation and grading activity when winds (instantaneous gusts) exceed 25 mph
- Limit the area subject to excavation, grading and other construction activity at any one time (BAAQMD 1999)

12. Natural Resource Conservation

12-1 Planning

Perform natural resource planning efforts where applicable as part of project and/or site-specific planning activities. Where feasible, project implementation strategies will incorporate sufficient planning time to collect and grow propagules necessary for native plant restoration efforts, including special status species enhancement pursuant to applicable permits.

12-2 Limit Disturbance

Limit the size and intensity of disturbance allowed within and adjacent to listed species habitats within each calendar year.

12-3 Enhance Habitat

Select project designs that promote and enhance special status species habitat restoration to the greatest extent practicable. Construction design specifications will be developed and evaluated collaboratively with natural resource specialists.

12-4 Reduce Social Trails

Reduce the extent of effects and prevent establishment of informal trails within areas supporting federally listed species or within recovery areas. Prioritization of trail removal activities will be coordinated with both natural resource specialists and trail planners.

12-5 Use Existing Disturbed Areas

Within natural areas, trails will be located on existing disturbed areas. Disturbed areas include currently sanctioned trails, informal trails, old roadbeds, and sidewalks. A multi-disciplinary natural resources team will review the conversion of informal trails to designated trails to ensure that the existing alignment had no negative effects on federally listed plant habitat. Boardwalks may also be incorporated into trail alignments to prevent off-trail use in habitat for special status species.

12-6 Coordinate with Draft Recovery Plan for Coastal Plants of the Northern San Francisco Peninsula

Final trail alignment and construction specifications will be consistent with the appropriate recovery plan objectives when trails fall within recovery unit areas. Within the lessingia recovery areas to be determined as part of the forthcoming final Recovery Plan, trails will be designed to the extent practicable to limit habitat effects, improve habitat values, promote flexibility for species population movement, encourage sand movement within the trail corridor and promote persistence of the dune annual community. Within the potential recovery areas for Raven's manzanita, dwarf flax and clarkia, trails will be designed to avoid serpentine outcrops and soils that are important recovery habitat.

12-7 Limit Increase in Impervious Surface

Construction activities within habitat for special status species will limit the loss or degradation of hydrological features and/or natural hydraulic processes, and avoid negative effects to surface drainage and groundwater flow rates and direction. Within habitats for federally listed plants, trail construction will be designed to limit an increase or concentration of impervious surface area. The use of pervious concrete for hardscaping will be considered as part of future project-specific trail planning efforts.

12-8 Buffers and Erosion Control

Buffers and erosion control measures will be incorporated into projects within habitats for federally listed species. Where practicable, new development and planned intensive human activities will be located at least 30.5 m (100 ft) from the edge of federally listed plant habitat. In instances where buffer distance is limited, the following measures may be implemented:

- Install protective fencing or other protective measures (such as low shrub buffers and boardwalks) around affected federally listed plant habitat
- Federally listed plant habitat areas adjacent to project sites will be monitored regularly. If these areas are found to be effected from increased visitor and tenant use, protective fencing or other measures will be either installed or modified

12-9 Develop Joint Study

Conduct a joint NPS/Trust study to determine restoration-compatible trail rotation in restored (non-remnant) lessingia habitat.

12-10 Develop Revegetation Plans

A site-specific revegetation plan will be prepared for each project with revegetation needs within habitat(s) for federally listed plants. Treatments will be consistent with the VMP (or any amendments to it). Revegetation of non-designated trail obliterations will be implemented in a timely manner, typically within six months of disturbance-related construction activities, depending upon habitat type, timing of trail work and availability of native plant propagules. If trail obliteration activities are discontinued due to lack of resources, an invasive non-native plant control program will be implemented until resources for obliteration and restoration become available again. To the maximum extent practicable, immediate revegetation will be implemented for federally listed species habitat and recovery areas that have been disturbed by construction, infrastructure repair, excavation, increased land use or other project-related activities.

12-11 Protect Soil

Develop best management practices for earth moving and other soil-related activities to avoid harming federally listed plants during project activities. Where practical and appropriate, these practices and conditions will include:

- Maintaining appropriate erosion and siltation controls during construction and stabilizing exposed soil or ecologically compatible fill after construction
- If fill is necessary, using only fill that is certified weed free, is compatible with local hydrologic and ecological conditions, and is appropriate for the enhancement of listed species restoration activities
- Avoiding over-compaction of fill soils
- Maintaining trails and structures to avoid effects to habitat and public safety
- Excavated materials will not be side-cast or spread into federally listed plant habitat
- Minimizing the potential effects of dust and debris generation during trail construction by wetting the soil or other applicable methods as appropriate
- Designing trail construction to limit any increase or concentration of impervious surface area within habitat for federally listed plants (a variety of pervious materials will be considered for trails surfaces)

12-12 Limit or Prevent Erosion

Limit or prevent erosion in areas of federally listed plants. Where practical and appropriate, measures will include:

- Limiting heavy equipment use in wet soil areas or where compaction could occur by minimizing the footprint of equipment access areas
- Including decompaction measures in site grading and drainage plans to promote groundwater percolation
- Returning disturbed soils to a stable condition after project completion
- Controlling erosion in cases where project operations will expose soils on steep slopes or otherwise increase erosion potential
- Identifying short-term erosion control measures for use during inclement weather, as well as long-term site stabilization measures, appropriate erosion control techniques and materials and specifications for installation and monitoring

12-13 Use Compatible Soils

Use compatible backfill soils (e.g., serpentine for serpentine) in cases where establishment of federally listed plants requires specific soil types or conditions. The final soil and topographic

conditions of excavated areas will be coordinated with professional restoration ecologists, hydrologists and/or geologists. If this clean fill is found to be incompatible with restoration and recovery objectives, it will be removed from the area.

12-14 Special Measures for *Lessingia*

In the event project activities require excavation of material directly within remnant lessingia habitat, the following measures will be implemented:

- All propagules will be gathered from the remnant population and stored separately from other gathered propagules (i.e., different species)
- To the greatest extent feasible, the hydrology and soil structure (texture, compaction, and composition) of the original habitat will be restored upon completion of excavation activities
- Propagules gathered from the remnant population will be planted throughout the restored area

12-15 Minimize Establishment of Invasive Species

Measures will be taken to minimize the establishment of invasive non-native species in disturbed soil areas. Such measures could include temporarily covering the soil and/or revegetation.

12-16 Protect Threatened and Endangered Species

Protect any threatened or endangered species known to occur within or adjacent to any construction work areas using fencing, signage, and other barriers. Protective measures will include:

- Qualified biological monitors shall be present for any activity within or adjacent to habitat
- Qualified biological monitors shall train construction workers in identification and ecological needs of the plant reproduction, and health of special status species
- Temporary construction barriers will be erected around listed species areas
- Staging areas, temporary stockpiles, and materials sorting activities will be kept away from listed species habitat as much as possible (these areas will also be fenced off to exclude pedestrian or pet access)
- Ensure that construction has only minimal influence on normal movement, migration, reproduction and health of special status species
- Waste, waste water, or other project-related materials generated on site shall be contained to ensure that none enters habitat for federally listed plants or other protected natural resource area
- Preventing unnecessary vehicular and human intrusion and use in native and federally listed plant habitat from adjacent construction, demolition, intensive special events and recreation activities (where necessary, formal or informal walking paths will be rerouted to accommodate the public)

12-17 Protect Listed Plant Species

Protect listed plant species by managing visitor and pet access in special status species habitat and recovery areas. Interpretive materials emphasizing resource and conservation values will be provided where visitor access within habitat for federally listed species will occur. These measures will include:

- Install interpretive signage to mark trails within endangered species habitat and associated recovery areas
- Incorporate boardwalks on trails where necessary
- Allow only seasonal access to certain trails where seasonal conditions will be expected to have a negative impact on special status species habitat or areas proposed for conservation of federally listed species (seasonal or permanent trail closures will be evaluated if protective measures fail)
- Restrict trail access to ranger-led activities where appropriate
- Install protective barriers, like fences, where trails pass through special status species habitats, and improve existing fences around these areas to prevent pet access where appropriate
- Monitor these measures to determine their effectiveness and evaluate if preventative measures are sufficient to ensure the conservation of listed species (if adverse impacts are observed within the management area, remediation measures will be developed in consultation with the USFWS)

12-18 Protect Migratory Birds

Implement the following measures to protect species protected under the Migratory Bird Treaty Act:

- Implement non-native wildlife control measures when necessary and feasible
- Cut vegetation only outside of bird nesting season (currently January 15 to August 15) unless monitoring indicates nesting birds are not present

12-19 Work Within Existing Disturbed Areas

Underground infrastructure work shall be staged within existing disturbed or developed corridors in order to prevent direct and indirect negative effects on federally listed plants. Where feasible, infrastructure maintenance activities will be minimized in habitat for federally listed species and recovery areas.

12-20 Prohibit Off-Trail Bicycle Use

Prohibit all off-trail bicycle use throughout the Presidio in order to prevent erosion, protect special status plant species and minimize damage to natural areas and wildlife habitat. In habitat for federally listed plants, pedestrian use will be constrained.

12-21 Protect Restoration Activities

Protect restoration activities by installing temporary fencing (as needed) around special status species habitat areas during restoration projects. Temporary fencing will remain standing while native species establish and spread (about 3 to 5 years, depending on climate-driven variables).

12-22 Coordinate Project Operations

Coordinate project operations involving vegetation or revegetation with natural resource staff to ensure project sites are revegetated using appropriate plants. To the maximum extent feasible, native plants used for revegetation will be grown from existing Presidio genetic stock and propagated either at the Presidio-based nursery itself or in accordance with established practices of the GGNRA nursery system. If onsite seeds and cuttings are unavailable, offsite sources will be evaluated to determine the most appropriate source for reintroduction, and documentation justifying the reintroduction decision will be prepared. Non-native plant control will continue after restoration until the following goals are met:

- Ensure the establishment of planted species by establishing success criteria and monitoring for federally listed species
- Prevent the spread of any opportunistic non-native species to existing Raven's manzanita, lessingia, dwarf flax and clarkia habitat
- Protect and conserve existing native plant material (cuttings and seed material) by conducting salvage efforts when determined appropriate and feasible by a natural resource specialist (salvage will be coordinated by a qualified biologist prior to the proposed activities)

12-23 Prevent Weeds

To the extent feasible, prevent the introduction of non-native plant and plant materials to listed species habitat and recovery areas. Preventative measures will include:

- Use certified "weed free" rice straw or other approved "weed-free" materials for erosion control and prohibit the use of any materials containing non-native plant seeds
- Ensure fill is purchased from a certified weed free source
- Clean all non-native plant seeds or material from equipment prior to it entering the special status species habitat area. Equipment traveling between areas will be cleaned each time it enters a special status species habitat site

12-24 Develop Monitoring Program

Develop site-specific, USFWS-approved biological monitoring protocols prior to implementing project activities. This strategy will involve periodic site visits by a qualified biologist, as well as biologist consultation prior to the commencement of any new activities in or adjacent to special

status species populations. The biologist will also monitor the removal and/or import of plant material or soil during implementation, to ensure salvage of as much native plant material as feasible.

12-25 Monitor Rare Species

Monitor and protect rare or endangered plant species, including any federal and/or state listed threatened or endangered species found to occur in the Presidio. Identified actions will be taken to recover these species, and their habitats will be enhanced to the greatest extent practicable. Any future rare or endangered species found on the Presidio will also be afforded similar appropriate protection and restoration measures.

12-26 Establish Monitoring Period

Establish a standard monitoring period and success criteria for projects affecting federally listed species, including photo documentation of the pre-project condition, restoration activities, and annual photo points